

The last paper read in this Section was *On the Rainfall of Scotland*, and contributed by Mr. Buchan. The paper was illustrated by a map of Scotland, showing the average annual rainfall of about 200 places, many of the averages being deduced from observations carried on through a long series of years. The map brought out the large rainfall in the west as compared with the east, a difference which was strongly marked even in the group of the Orkney Islands. The average rainfall in the west, at stations removed from the influence of hills, was from thirty-six to about forty inches; but on the east coast, in similar situations, the rainfall was as low as from twenty-four to twenty-eight inches. In casting the eye towards the watershed of the country running north and south, it was seen that in ascending towards it from the west, there occurred a rapid, but by no means uniform, increase; and in descending from it towards the east, a rapid, but by no means uniform, decrease. The largest rainfall occurs almost wholly among the hills forming the watershed north of the Forth and Clyde. The places characterised by the heaviest rainfall are, so far as observation has yet enabled us to determine, the following:—Glencoe, immediately under Rest-and-Be-Thankful, 128 inches annually; Ardlin, head of Loch Lomond, 115 inches; Bridge of Orchy, 110 inches; Tyndrum, 104 inches; Glen Quoich, in the south-west of Invernesshire, 102 inches; and Portree, Skye, 101 inches. At no great distance from several of these places the rainfall is by no means excessive, thus pointing out an enormous difference of climate between places not far apart. Along the watershed of that part of Scotland which lies south of the Forth and Clyde, no such excessive rainfall occurs, the highest hitherto observed being only 71 inches, Ettrick Pen Top, 2,268 feet high. This diminished rainfall in the south as compared with places similarly situated further north is doubtless due to the mountains of Ireland to the south-west, which partially drain the rain-bringing winds of their moisture before they arrive at these parts of Great Britain. The distribution of the rainfall is very instructive in many districts, as in the valley of the Forth, from the head of Loch Katrine to North Berwick, where the amount varies from ninety-one to twenty-four inches; in Clydesdale, where the quantity is greatest at the head and foot of the valley respectively, being considerably less at intermediate places; and along Loch Linnhe and through the Caledonian Valley, where the variations of the rainfall were excessive. In all these districts, as well as elsewhere, many cases might be referred to, showing that the amount of the rainfall is very far from being determined by mere height. In truth, it is to local considerations we must chiefly look for an explanation of the mode in which rain is distributed over any district; and hence, in estimating the rainfall, particularly in hilly districts, no dogmatic rule can be laid down which can approximate in accuracy the result arrived at by one skilled in such matters and who is at the same time well acquainted with the district. If those districts were shaded off in which the rainfall did not exceed 30 in. annually, the great grain-producing district of Scotland would be indicated; and it was interesting to note that in those districts which produced the best wheat the rainfall was lower than elsewhere, being in many places as low as 24 in. There are about fifty places at which observations have been made for periods varying from twenty to forty-five years. On comparing the average of the three driest years at each of these places with its average, the amount of the deficiency is found to vary exceedingly, being as much as one-third in some places and as little as one-ninth in others.

Mr. Bateman expressed his great satisfaction that Mr. Buchan had stuck to facts instead of theorising. He went on to say that the correction given for the three dry years was just as fallacious as the correction for altitude. A proposed rule had been laid down of an increase in the rainfall of one and a half per cent. for each 100 feet of elevation, but subsequently that one and a half had been changed to two and a half. Mr. Bateman said that the formula for the three dry years was that for the height. In point of fact it was impossible to lay down any rule that would give accurate results.

Mr. Symons drew attention to the fact that the ratio of the three dry years depended very much on the length of period involved, and showed that the epoch of dry years in the instances quoted varied almost precisely with the length of those averages.

Mr. Bateman and Mr. Symons spoke strongly in favour of the work performed by Mr. Buchan, and of the excellent operations of the Scottish Meteorological Society.

Mr. Milne Home made a few appropriate remarks in reply.

MAXIMUM VELOCITY OF METEORIC STONES REACHING THE SURFACE OF THE EARTH

IN Prof. Nordenskjöld's account of the Aerolitic Shower which took place near Hessel, in Sweden, on the 1st of January, 1869, he mentions, as a remarkable fact, that stones weighing two pounds, which struck the ice of the Larsta-Viken, failed to penetrate, making holes only three or four inches deep in the ice and rebounding. (Vide the *Academy*, Dec. 15, 1870.)

The small velocity retained by these stones at the time of striking the earth is, doubtless, owing to the resistance of the air, and, consequently, is not an indication of the velocity which they had upon entering the atmosphere.

Stones thus penetrating the atmosphere from interplanetary space, would be moving in a resisting medium under the joint influence of their original velocity of translation and the constant action of terrestrial gravity. In the case of small masses, the resistance of the medium would very speedily produce retarded motion; and before traversing twenty or thirty miles of air, they would probably move with a velocity approximating uniformity, and under the action of gravity alone. In other words, they would gradually lose their original velocity of translation, and, descending, nearly or quite vertically, under the action of gravity, would ultimately attain a maximum velocity under the opposing influences of the resisting and accelerating forces, and then descend to the earth with this uniform velocity.

Thus, for example, a rifle bullet shot obliquely into deep water, would very soon lose the horizontal component of its velocity, while the vertical motion would be so rapidly retarded that, at a comparatively short distance below the surface of the water, it would begin to descend vertically with the very moderate uniform motion resulting from the resistance of the liquid and the constant action of gravity.

In like manner, no matter how great the velocity with which a meteoric stone enters the atmosphere, the enormous resistance which it encounters must operate ultimately to produce a similar result, although, in some cases of oblique incidence, the horizontal component of velocity is not entirely lost before reaching the earth.

It is well known that this maximum or limiting velocity of a falling body is attained when the required velocity is such that the resistance is at each instant equal to the weight of the moving body. In the case of small masses moving in the air, it may be shown that this velocity is quite moderate.

The principles of dynamics furnish the means of determining the resistance of a given body moving in a medium of given density when the size of the body and its velocity are known.

Let A = area of cross-section of body at right angles to direction of motion.

D = weight of unit volume of medium (air).

v = velocity of moving body (meteoric stone).

g = acceleration by gravity in a unit of time.

k = a constant co-efficient, deduced from experiment, depending upon the shape of the moving body.

Then we have,

$$\text{Resistance} = k \times A \times D \times \frac{v^2}{2g}$$

Hence, by the conditions under which, as above given, v becomes a maximum, if w = weight of the moving body or stone, we have,

$$k \times A \times D \times \frac{v^2}{2g} = w \therefore v = \sqrt{\frac{2g \times w}{k \times A \times D}} \quad (a)$$

Applying this formula (a) to the case of a meteoric stone weighing two pounds moving in the air:—let us assume it to be a cubical mass, having a specific gravity of 3 in relation to water as unity. Then its volume = 18.482 cubic inches, and the area of one of its faces = 6.9903 square inches = 0.048544 square feet. Hence, assuming the resistance to act at right angles to the face of the cube, and taking the pound and foot as units, we have—

A = 0.048544 square feet.

D = 0.0807288 pounds = weight of cubic foot of air at 0° C.

w = 2 " " " " stone.

g = 32.1928 feet per second.

v = required maximum velocity in feet per second.

Hence by formula (a) :—

$$v = \sqrt{\frac{2 \times 32 \cdot 1928 \times 2}{k \times 0.048544 \times 0.0807288}} = \sqrt{\frac{128 \cdot 77}{k \times 0.0039189}}$$

$$= \sqrt{\frac{32859}{k}}$$

$$\text{Or } v = \frac{181 \cdot 27}{\sqrt{k}} \text{ in feet per second.}$$

Assuming $k = 1 \cdot 3$,* we obtain,
 $v = 158 \cdot 99 (= 159)$ feet per second, as the maximum velocity attained by such a stone in falling to the earth. This velocity does not exceed *one-tenth* of the initial velocity of a rifle bullet. And, as the *penetrating power* of a given projectile is proportional to the *square* of its velocity, its power of penetrating the ice would only be *one-hundredth part* as great as that of a projectile of similar mass and dimensions moving at the rate of a rifle bullet. Hence we need not be surprised that the ice was not penetrated more than three or four inches.

If the same mass of stone (two pounds) were *spherical* in form instead of *cubical*, its diameter would be $3 \cdot 2803$ inches = $0 \cdot 27336$ feet, and $A = 0 \cdot 058689$ square feet. In this case, we may assume $k = 0 \cdot 7$ †. Hence, by the formula (a), we obtain,
 $v = 197 \cdot 05$ feet per second: so that in this case likewise its velocity would be quite low, and its penetrating power *very insignificant*.

Of course, in the case of *large* meteoric stones the value of v would be much greater.

JOHN LE CONTE

ASTRONOMY

The Solar Eclipse of 1868 ‡

ADEN was chosen as the observing-station because from the general nature of its climate it was thought that a satisfactory view of the phenomena that took place during the eclipse might fairly be expected, and also because, as it was far removed from the stations of the French and English expeditions, any observations taken there would prove of considerable importance. The observers were Prof. Edmund Weiss (the leader) Prof. Oppolzer, and J. Rziha, already known for his observations of the eclipse of 1867.

On the morning of the eclipse (Aug. 17) the state of the atmosphere proved unfortunately anything but favourable for astronomical investigation, owing to the presence of a great amount of cloudiness. According to Oppolzer the beginning of the totality was $18^h 29^m 30^s \cdot 0$ (Aden mean time), the end $18^h 33^m 24^s \cdot 6$.

A few moments before the total disappearance of the sun, Weiss saw on it a beautiful carmine red border or streak, in the middle of which arose a similarly-coloured complicated prominence (No. 1) which lasted for a few seconds. Half a minute later ($18^h 30^m 2^s$) a second prominence (No. 2) appeared, long, thin, and in shape resembling a slightly bent finger; nearly two minutes later ($18^h 31^m 58^s$) he noticed a third smaller, hill-shaped, or conical prominence (No. 3). Just at the end of the totality another beautiful red border appeared, on the outer edge of which was a gleam of deep blue, most intense at the point of junction with the red, and rapidly fading away on the outside into the background.

Some English officers stationed a short way off also noticed the first two prominences (which they say were visible to the naked eye) and the red border at the end of the totality, but they failed to see prominence No. 3, perhaps for want of sufficiently powerful or properly adapted instruments.

Oppolzer's observations coincided with those of Weiss, except that he failed to see prominence No. 3 on account of the interference of passing clouds, though he suspected its presence from a certain red appearance at the spot indicated by Weiss. Satisfactory observations of the corona were rendered impossible by the state of the atmosphere.

* For cubes moving in water the experiments of Du Buat and Duchemin give $k = 1 \cdot 28$.

† For spheres moving in air the experiments of Robins and Hutton give for velocities:—

$v = 3 \cdot 28, 16 \cdot 4, 82, 328$ feet per second.
 $k = 0 \cdot 59, 0 \cdot 63, 0 \cdot 67, 0 \cdot 71$.

‡ *Astronomische Nachrichten*, No. 1836-1837: "Account of the observations of the Austrian Expedition sent to Aden to watch the total solar eclipse of 1868."

Rziha's part was confined to the spectrum, and his account is that simultaneously with the disappearance of the last sunbeam, Fraunhofer's lines entirely vanished, the spectrum became continuous and remained so to the end of the totality. All his efforts to detect any reversal of the lines proved ineffectual. Just before the reappearance of the sun, thin clouds intervened and hid the greater part of the corona, so that the principal sources of light were the red border and the prominences. At this moment the more refrangible rays from the green disappeared gradually, and only the red end of the spectrum remained, consisting of deep red, carmine, orange, feeble yellow, and the faintest possible tinge of green, at the same time this remaining part became discontinuous owing to the appearance of dark lines in it, which did not, however, coincide with any of the principal lines of the ordinary spectrum. The disappearance of the dark lines, Rziha seems to think, would connect the corona with a solar atmosphere; and he suggests that the lines or streaks which appeared afterwards were due to absorption by the water-vapour of our own atmosphere.

PHYSICS

On a Quantitative Method of Testing a "Telegraph Earth," by W. E. Ayrton*

THE method used up to the present time for testing a telegraph earth has been *qualitative* only. As, however, the electrical condition of every "earth" is of great practical importance, it is necessary that some accurate *quantitative* method should be devised, in order that every telegraph office may ascertain whether the resistance of their earth is higher or lower than the maximum resistance allowed. The principal difficulty met with is that, if the resistance between two earths be measured successively with positive and negative currents, the same result is not obtained. Consequently the ordinary law for a Wheatstone's Bridge, or Differential Galvanometer, would not hold true. This difficulty, however, has been overcome in this paper, and formulæ are developed suitable for a Wheatstone's Bridge, a Differential Galvanometer, or a Galvanometer of which the law of the deflections is known.

The details of some experiments are also given, and a particular instance is mentioned in which a much better "earth" was obtained by burying the plate in the upper stratum of soil than by burying it much deeper, on account of a bed of sandstone that existed at about fifteen feet below the surface.

SCIENTIFIC SERIALS

THE *American Naturalist* for September commences with an article by Mr. W. J. Hays, entitled "Notes on the range of some of the Animals in America at the time of the arrival of the white men." The moose, now almost entirely driven out of the United States, was, at the time of the first European settlement, found as far south as New York city; the range of the cariboo was not more extensive than it is now, although fossil remains have been found as far south as the Ohio; the musk-ox is not mentioned by the early travellers; but the common deer (*Cervus virginianus* and *C. campestris*) was everywhere represented as existing in incredible numbers. The Wapiti deer was found all along the coast from Canada to the Gulf of Mexico; the bison (improperly called the buffalo by the early settlers), also ranged along the coast from the valley of the Connecticut to Florida, and roamed over the entire country now known as the United States, and extending as far north as the sixtieth parallel in British America. Mr. Hays reckons that at the present time not fewer than half-a-million bisons are annually destroyed by the hand of man. The red fox existed in America before the advent of the white man, in addition to the gray species, notwithstanding assertions to the contrary; wolves were everywhere abundant; as also was the beaver; the jaguar, not now found east of Texas, occurred in the mountains of North Carolina as recently as 1737; the dog was found in all parts of the country; and, from the descriptions, must have been of the same species as those now found with the Indians of the plain. The only other original article in the number is "On the Food and Habits of some of our Marine Fishes" by Prof. A. E. Verrill.

THE most important paper in the *Journal of Botany* for September is an article by Mr. J. G. Baker "On the Dispersion of Montane Plants over the Hills of the North of England." Mr.

* From the Proceedings of the Asiatic Society of Bengal.